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Electroless Nickel MIL-C-26074 Callout Requirement Class 1350-400°F for 3+ hr embrittlement only for steel > Rockwell C40 no treatment for other material Class 2550 °F for 2+ hr 650 °F for 1-1.5 hr hardness must be > 800 HK100 Class 3360 to 390°F for 1-1.5 hr for non heat-treatable aluminum Class 4240 to 260°F for 1-1.5 hr for heat-treatable aluminum Grade A1.0 mil minimum thickness Grade B0.5 mil minimum thickness Grade C1.5 mil minimum thickness (thickness order does not match gradeorder best to specify on print) This specification was discontinued for years and then reinstated at MIL-C-26074E then superseded by AMS-C-26074E which is virtually identical to the MIL-C-26074E specification. Depending on the print date, "MIL-C-26074", "AMS-C-26074" or "AMS2404" may be referenced - scroll down to investigate these various specifications. Notes to purchaser ... Correct callouts for aluminum are Electroless Nickel per MIL-C-26074 Class 3 or Electroless Nickel per MIL-C-26074 Class 4 depending on whether the alloy will be affected by the higher temperature of the Class 3 bake. AA6061-T6, for example, would normally require a MIL-C-26074 Class 4 processing, since T6 will lose its temper (ha!) well below 360°F. Other basis materials should specify Electroless Nickel per MIL-C-26074 Class 1, if no heat treatment is required other than the embrittlement bake for hardened steel (> Rockwell C40). If a bake to increase hardness is desired, specify Electroless Nickel per MIL-C-26074 Class 2, which specifies baking to achieve a hardness greater than 800 Knoop; the specification shows a table of time and temperature that should achieve this result. Purchasing due diligence should include a look at the shop's bath testing records, acceptance test records, and quarterly test results. Be sure to specify phosphorus content on your purchase order if it is not specified on the print. Note also that your supplier is required to bake hardened steels for embrittlement relief; however, he is not required to do embrittlement testing unless specified on your print or by contract or purchase order. If embrittlement testing is required, you should supply test specimens fabricated from your alloy per ASTM F519 diagrams. Hardened steels and titanium are candidates for hydrogen embrittlement. Note to engineer: A common weakness of the AMS/MIL-C-26074 and AMS2404 specifications is that deposited phosphorus content is not specified. Phosphorus content in the deposit affects corrosion resistance, brightness and hardness of the plating. If you are working on a new application, you should consider the ASTM B733 specification. If you decide to use the MIL-C-26074 or AMS2404 specification, consider specifying phosphorus content in the print notes: you may specify as low-phos, mid-phos or high-phos, or you may nail down you requirements with a specific percent phosphorus in deposit. Use the ASTM B733 specification for guidance, since specifying a non-standard percentage range may cause procurement problems or price increases. Note to supplier: See complexing titrations for analysis instructions for nickel metal in electroless nickel baths. Bath Testing ¶ 3.3.1.2: test plan to be established by supplier and approved by customer Coupon Testing - monthly ¶ 4.4.2: embrittlement ¶ 4.4.4: plating hardness Coupon Testing - quarterly ¶ 4.4.1: destructive adhesion ¶ 4.4.5: destructive thickness ¶ 3.3.4: corrosion resistance Coupon/Part Testing - per lot ¶ 4.4.1.2: coating thickness ¶ 4.4.3: adhesion bend test Electroless Nickel ASTM B733 Callout Requirement Type Ixx% phosphorus Type III1-3% phosphorus Type III2-4% phosphorus Type IV5-9% phosphorus Type V10+% phosphorus Class 1No heat treatment Class 2260 to 400°C for 2-4 hr hardness must be > 850 HK100 Class 3180 to 200°C for 1 hr min embrittlement bake for steels Class 4120 to 130°C for 1 hr min for non heat-treatable alloys Class 5140 to 150°C for 1 hr min for non heat-treatable alloys Class 6300 to 320°C for 1 hr minadhesion bake for titanium alloys The active specification is ASTM B733-04 and is available from ASTM International. We believe ASTM B733 is the best specification to use for electroless nickel, principally because it requires specification of phosphorus content the deposited nickel. Higher phosphorus content improves corrosion resistance and microhardness while reducing the brightness and electrical conductivity. ASTM B733 lets a purchaser nail down his requirements in the specification callouts, thereby ensuring consistent results and improving chances that alternate sources will deliver similar product. Notes to purchaser ... Notice that the heat treatment classes do not align with the AMS2404/MIL-C-26074 specification. Correct callouts for aluminum are Electroless Nickel per ASTM B733 Class 4 or Electroless Nickel per ASTM B733 Class 5 depending on whether the alloy will be affected by the higher temperature of the Class 5 bake. ASTM B733 Class 1 gets no heat treatment, and ASTM B733 Class 3 has been added to specify an embrittlement bake for hardened steel. ASTM B733 Class 2 is the only one of the class call outs that aligns with the more familiar MIL-C-26074; however, the target hardness is 850 HK100. The purchaser should include Type and Class in print note or purchase order, and should not expect a plating supplier to know whether 304 Stainless should receive an embrittlement bake or not. As always, the purchaser should ensure specification compliance with regular inspection of bath test records and periodic test results, and should also encourage use of an independent lab. Note to supplier: ASTM B733 requires routine testing, including setting of control limits for SPC of the ENi bath used to plate parts that are certified to the specification. It does not specifically require testing of prep baths, but soap, acid and zincate baths are just as important as the ENi bath to ensure plating adhesion. See complexing titrations for analysis instructions for nickel metal in electroless nickel baths. Bath Testing ¶ 6.5.1: temperature & pH ¶ 6.5.1: nickel -10% +0% ¶ 6.5.1: hypo -10% +0% ¶ 6.5.1: SPC to set control limits Coupon Testing - monthly ¶ 7.3.1: phosphorus content ¶ 7.3.2: plating microhardness Coupon/Part Testing - per lot ¶ 7.2.2: coating thickness ¶ 7.2.3: adhesion bend test ¶ 7.2.4: porosity Electroless Nickel AMS-C-26074 Callout Requirement Class 1350-400°F for 3+ hr embrittlement only for steel > Rockwell C40 no treatment for other material Class 2550 °F for 2+ hr 650 °F for 1-1.5 hr hardness must be > 800 HK100 Class 3360 to 390°F for 1-1.5 hr for non heat-treatable aluminum Class 4240 to 260°F for 1-1.5 hr for heat-treatable aluminum Grade A1.0 mil minimum thickness Grade B0.5 mil minimum thickness (thickness order does not match gradeorder best to specify on print) AMS-C-26074 has been cancelled at AMS-C-26074E as of July 2011. The AMS specification is virtually identical to MIL-C-26074E. Correct callouts for aluminum are Electroless Nickel per AMS-C-26074 Class 3 or Electroless Nickel per AMS-C-26074 Class 4 depending on whether the alloy will be affected by the higher temperature of the Class 3 bake. AMS-C-26074 Class 1 gets no heat treatment unless the basis material is hardened steel (> Rockwell C40) which always gets an embrittlement bake. AMS-C-26074 Class 2 must be baked to achieve a hardness greater than 800 Knoop, and the specification shows a table of time and temperature that should achieve this result. Purchasing due diligence should include periodic inspection of the shop's bath testing records, acceptance test records, and quarterly test results. Bath records should include soap and etch tanks, as well as deox and zincate tanks for aluminum material. If a purchaser is receiving a cert to the AMS specification, he should ensure that the plater has a current copy of the specification. The AMS/MIL-C-26074 specification does not specify phosphorus content in the deposit, although phosphorus content affects corrosion resistance, brightness and hardness of the plating. If you are working on a new application, you should consider the ASTM B733 specification. If you are purchasing to an existing print, you should specify the phosphorus content on your purchase order. You should not leave this specification in doubt. Bath Testing ¶ 3.3.1.2: test plan to be established by supplier and approved by customer Coupon Testing - monthly ¶ 4.4.2: embrittlement ¶ 4.4.4: plating hardness Coupon Testing - quarterly ¶ 4.4.1: destructive adhesion ¶ 4.4.5: destructive thickness ¶ 3.3.4: corrosion resistance Coupon/Part Testing - per lot ¶ 4.4.1.2: coating thickness ¶ 4.4.3: adhesion bend test Electroless Nickel AMS2404 Callout Requirement Class 1350-400°F for 3+ hr embrittlement only for steel > Rockwell C40 no treatment for other material Class 2450 °F for 4+ hr hardness must be > 800 HK100 Class 3360 to 390°F for 1-1.5 hr hardness must be > 800 HK100 Class 3360 to 390°F for 1-1.5 hr for non heat-treatable aluminum Class 4240 to 260°F for 1-1.5 hr for heat-treatable aluminum All Classes 1-13% phosphorus by weight AMS2404 is the successor to the AMS/MIL-C-26074 specifications. The monthly coupon test regimen is more rigorous than the previous specifications. The latest revision, AMS2404F, is available from SAE International. Correct callouts for aluminum are Electroless Nickel per AMS2404 Class 3 or Electroless Nickel per AMS2404 Class 4 depending on whether the alloy will be affected by the higher temperature of the Class 3 bake. Tempered aluminum (AA6061-T6 for example) should not be baked above 260°F. AMS2404 Class 1 gets no heat treatment unless the basis material is hardened steel (> Rockwell C40) which always gets an embrittlement bake. AMS2404 Class 2 must be baked to achieve a hardness greater than 800 HK100, and the specification shows a table of time and temperature that should achieve this result. As with the older AMS/MIL-C-26074 specs, the phosphorus content should be specified by percentage on either print or purchase order, and monthly test results, preferably from an independent test lab, should be checked to ensure that the supplier is hitting the number. Results from salt spray testing are also important since this is the validation of phosphorus content and plating porosity. As always, purchasing due diligence should include periodic checking of the supplier's bath records, including prep baths. A bit of inexpensive due diligence may save a very expensive field failure. Don't rely on a certificate of conformance without due diligence. Bath Testing ¶ 4.4.3: Control factors must include: surface preparation (including strike), plating bath composition and control limits, plating bath temperature limits and controls, thermal post treatment times and temperatures, test methods, and periodic test plan. Coupon Testing - monthly ¶ 3.4.3: corrosion resistance ¶ 3.4.4: plating hardness ¶ 3.4.5: embrittlement ¶ 3.4.6: internal stress ¶ 3.4.7: phosphorus content Coupon/Part Testing - per lot ¶ 3.4.1: coating thickness ¶ 3.4.2: adhesion bend test Electroless Nickel AMS2405 Specification Requirement "low" phosphorus Less than 8% by weight Specification non-current AMS2405C has been discontinued. Bath Testing periodic testing of cleaning and plating solutions is specified Coupon Testing - periodic ¶ 3.4.1: phosphorus content ¶ 3.4.3: adhesion ¶ 3.4.4: corrosion resistance Coupon/Part Testing - per lot ¶ 3.4.2: coating thickness Electroplated Nickel FED QQ-N-290 Callout Requirement Class 1Corrosion protection Class 2Engineering plating (for wear and/or lubricity) SB Single layer - Bright SD Single layer - Dull M Multi layer Grade A1.6 mil plate thickness Grade C1.0 mil plate thickness Grade E0.6 mil plate thickness Grade F0.4 mil plate thickness (Note: See complexing titrations for analysis instructions for nickel sulfate and nickel chloride concentrations in Watts nickel baths.) Newer prints may reference the superseding AMS QQ-N-290 specification. The QQ-N-290 is required reading for any shop doing nickel electroplating. The print note for the high corrosion resistance is Nickel Plate per QQ-N-290 Class 1 (Grade A through C). When plated on steel, this requires a duplex nickel process with careful control of the sulfur content. This multi-layer plating has been shown to increase corrosion resistance over a single plating material of the same thickness. Similar multi-layer nickel plating is required to meet the ASTM B456 specification for chrome over nickel plating, and this ASTM specification has a lot of good information about the process and methods of testing sulfur content in nickel plating. Nickel Plate per QQ-N-290 Class 1 or Nickel Plate per QQ-N-290 Class 2 can be achieved with either a Watts or sulfamate bath, but the properties of the deposit (e.g. internal stress, brightness, corrosion resistance), are significantly different for these two types of plating. If the bath is not specified, a careful plater will confirm with the purchaser. Ideally, the bath type will be mentioned on the cert. As always, a purchaser must ensure that a supplier is doing the required testing of all process baths, including cleaning and prep baths. The typical process for aluminum includes a zincate or double zincate ENi process for underplating, and the prep and strike baths (soap, nitric acid, zincate, ENi strike, Woods strike) will be more important than the electrolytic nickel bath for final plate adhesion. Prep and strike baths are also crucial for other materials; however, the prep process on steels, copper, etc. is less tedious than for aluminum or magnesium. If the material is hardened steel, the purchaser should check the monthly embrittlement test results. Don't rely on a certificate of conformance without due diligence. Bath Testing ¶ 4.3.1: processor to keep records of all chemical concentrations and additions Coupon Testing - monthly ¶ 4.5.1: coating thickness ¶ 4.5.2: adhesion bend/knife test Electroplated Nickel AMS2403 Specification Requirement Thickness Must be on print AMS2403L is the current revision available from SAE International. See notes on AMS2403. The correct print callout would be "Nickel Plate per AMS2423". Woods, Watts, sulfamate, or other bath may be used. Hardening agents may be used. (Note: See complexing titrations for analysis instructions for Watts nickel baths. The low-stress requirements are normally met using a sulfamate nickel bath with no additives (brighteners, stress-reducers, etc.) that could increase internal stress or reduce the corrosion resistance of the coating. (Note: See complexing titrations for analysis instructions for Watts nickel that can also be used for sulfamate and nickel chloride concentrations in sulfamate nickel baths.) Bath Testing ¶ 4.2.2: periodic testing of cleaning and plating solutions to ensure specification conformance Coupon Testing - periodic ¶ 3.4.2: hardness ¶ 3.4.3: residual stress ¶ 3.4.5: heat resistance ¶ 3.4.6: corrosion resistance ¶ 3.4.7: embrittlement Coupon/Part Testing - per lot ¶ 3.4.1: coating thickness ¶ 3.4.4: adhesion test ¶ 3.5: general quality

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